DOCUMENT RESUME

ED 194 833 CG 014 774

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TITLE Student Attrition in a Computer-Managed Course and Cognitive Attributes. Summary.
PUB DATE 80
NOTE 14p.; Paper presented at the Annual Convention of the American Psychological Association (88th, Montreal, Quebec, Canada, September 1-5, 1980).

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Ability; Abstract Reasoning; Academic Achievement; *Aptitude; *Cognitive Style; Comparative Analysis; Concept Formation; Failure; *Individual Differences; *Personality Traits; Postsecondary Education; Prediction; *Student Attrition; Trainees
IDENTIFIERS *Naval Electronics School

ABSTRACT

The incorporation of computer-managed instruction into an academic program made it necessary to identify those cognitive styles, abilities, and aptitudes which were relevant to the success or failure of trainees in the Navy's Basic Electricity and Electronics (BE/E) School in order to minimize the attrition rate. Measures of 6 styles, 6 abilities, and 12 aptitudes were administered to 172 BE/E trainee graduates and 35 BE/E failures. Stepwise discriminant analyses were computed to determine what linear combinations of tests optimally differentiate between BE/E graduates and failures. Classification equations and predictive accuracies were established for each derived discriminant function as a means of evaluating its adequacy. Results indicated that failures and graduates of BE/E School significantly differed in certain cognitive styles, abilities, and aptitudes. Failures as contrasted with graduates possessed: (1) field-dependent and broad conceptualizing styles; (2) poor verbal comprehension, ideational fluency, general reasoning capacity, and inductive ability; and (3) low quantitative, technical, verbal, and general aptitude. (Author)

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Summary

Student Attrition in a Computer-Managed Course and Cognitive Attributes

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Problem

The incorporation of computer-managed instruction (CMI) into the Navy's Basic Electricity and Electronics (BE/E) Preparatory School has raised an important issue, specifically: Which students are likely to succeed in, and which attrite from, this course? To answer this question, those cognitive styles, abilities, and aptitudes that are relevant to a student either failing or graduating BE/E School must be identified.

Cognitive styles refer to the dominant modes of information processing which people typically employ when perceiving, learning, or problem solving, e.g. field independence. Test of abilities allude to the intellectual capabilities of individuals which are general and pervasive to the performance of many tasks, e.g. verbal comprehension. Measures of aptitudes are used to select personnel to perform tasks which demand specific skills and to find the right person for a certain job. These tests assess specific content or skill, e.g., mathematics or mechanics, and they serve chiefly as classification instruments for making job decisions and school assignments for individuals.

Objectives

The objectives of this research were:

1. To determine how failures and graduates of BE/E School differ in their cognitive styles, abilities, and aptitudes.
2. To derive classification functions which use measures of cognitive attributes to predict the probability of student success and failure in BE/E School.

Approach

Subjects

The subjects were 207 BE/E trainees -- 172 graduates and 35 failures -- at the Naval Training Center, San Diego. Before beginning BE/E orientation, the subjects were administered 12 tests--six designed to measure their cognitive styles; and six, their abilities. When these individuals entered the service their aptitudes were measured by the 12 subtests of the Armed Services Vocational Aptitude Battery (ASVAB).

Measurement Instruments

Table 1 presents the 24 tests used in this study, along with the abbreviation and a brief description of each. The six tests designed to measure cognitive styles were selected because of their implications for

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adaptive instruction (Kogan, 1971); and the six tests designed to measure abilities, because they represent various types of information-processing tasks (Carroll, 1974, 1975) and are apparently relevant to the BE/E subject matter. The ASVAB subtests were selected as measures of aptitudes because they are used as a basis of assigning personnel to different types of Navy schools. All of the tests are (1) relatively independent, (2) moderate to high in reliability, (3) paper-and-pencil in nature, and (4) fairly short in duration.

Analyses

Seven stepwise discriminant analyses were computed to determine what linear combinations of tests optimally differentiate between BE/E failures and graduates. These separate analyses were calculated using

(a) indices of cognitive styles, abilities, and aptitudes only; (b) the three two-way interactions of these different types of measures; and (c) the one three-way interaction of these distinct kinds of test scores.

Classification equations and predictive accuracies were established for each derived discriminant function as a means of evaluating its adequacy. By classifying subjects initially used to produce the discriminant functions and comparing predicted group membership with actual group membership, the proportion of correct classifications could be empirically determined which served as an index of the goodness of the discriminations.

Results

The discriminant analyses and their associated statistics, which are summarized in Tables 2 and 3 respectively, indicated that graduates and failures significantly differed in certain cognitive styles, abilities, and aptitudes. Specifically, failures--opposed to graduates--tended to

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have (a) field-dependent and broad conceptualizing styles; (b) poor verbal comprehension, ideational fluency, general reasoning capacity, and inductive ability; and (c) low quantitative, technical, verbal, and general aptitude.

The prediction results based upon the derived classification functions are tabulated in Table 4. These revealed the following. Assuming that it

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is probable for a student to graduate or fail BE/E School, the percentage of correct classifications of actual failures ranged from 68.60% using

measures of cognitive styles only, 74.30% using tests of abilities only, and 77.10% using indices of aptitudes only. This rate increased to 80.00% by using tests of styles and aptitudes, abilities and aptitudes, or all of these different kinds of tests together. Adjusting the prior probabilities of a student failing or graduating BE/E School, the proportion of correct classifications of actual graduates varied from 99.40% using tests of cognitive styles only, 96.50% using measures of abilities only, and 97.10% using indices of aptitudes only. This rate ranged from 94.80% to 96.50% using various combinations of these different types of tests.

These data demonstrated that the hit rates for actual failures were much higher when the equal probability assumption was made. Of prime concern was the capability to identify, as accurately as possible, those students who were likely to fail BE/E School so that corrective action could be taken to reduce the attrition rate. Therefore, it appeared that the equal probability assumption was more effective than the adjusted probability assumption. It should be pointed out, however, that adjusting the classification scores of subjects according to prior probabilities is often performed when it is desired to minimize misclassification costs and/or when the size of the actual groups is grossly different.

Discussion and Conclusions

The results have several implications for the identification of probable student graduates and failures within BE/E School. BE/E graduates were more field-independent than failures. Successful students had an information-processing style that was analytical in nature and were inclined to distinguish objects or figures from their backgrounds or contexts in a differentiated manner. In light of the subject matter covered by BE/E

School, it seemed reasonable to conclude that students who are more analytical in their information processing are more likely to complete the course. Also, a field-independent mode of processing is associated with an impersonal orientation; and a field-dependent mode of processing, a personal orientation. Thus, field-independent students may be more successful than field-dependent students in a CMI course, which includes a minimal amount of interpersonal interaction between the instructor-- whose new role is that of learning supervisor--and the student, and among the students. Field-independent students may be more likely to succeed under these circumstances, and field-dependent students to fail.

Graduates differed from failures in their conceptualizing style. Successfull students tended to organize or sort objects to maximize similarities or differences among them. The fact that graduates used more categories in an object-sorting task than failures indicated that they usually exercise more critical judgment in recognizing ambiguities among objects or events. Therefore, they may be more successful in mastering instructional materials--especially, subject matter as theoretical and technical as electricity and electronics.

Finally, graduates also differed from failures in abilities and aptitudes. With respect to abilities, graduates were significantly superior to failures in verbal and reasoning abilities. The former surpassed the latter in verbal comprehension and ideational fluency as well as general and inductive reasoning. Regarding aptitudes, graduates manifested more quantitative and technical skill as well as more general and word knowledge than failures. The former outdid the latter in numerical operations, arithmetic reasoning, and mathematical knowledge, in addition to electrical, mechanical, and scientific comprehension. Also, graduates were superior to failures in word knowledge and in general information.

Seven different pairs of classification functions were established for predicting the probability of a student failing or graduating from BE/E School. These classification equations require, as input, measures of cognitive styles, abilities, and/or aptitudes. The prediction results based upon these distinct classification functions vary in their precision in terms of hit and miss rates. The derived classification equations also differ in the efficiency of their potential application to BE/E School. The ASVAB is already being given to all newly acquired Navy enlisted personnel. Therefore, the set of equations that employ aptitudes assessed by the ASVAB can be implemented immediately. Measures of cognitive styles and abilities, which are integral components of the remainder of the derived classification functions, could be acquired by administering the appropriate tests to students prior to their entry to BE/E School. Information obtained could be used (1) to increase the accuracy of prediction of student failure or success in BE/E School; (2) to identify those students who are deficient in certain cognitive styles and abilities, so that they can be given pre-training to increase their chances of success in BE/E School; and/or (3) to specify those trainees who could be assigned instructional materials specially designed to accommodate differences in cognitive styles and abilities, to minimize their failure rate within BE/E school.

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Table 1

Cognitive Characteristics Measured

Cognitive Characteristic	Abbreviation	Description	Measurement Instrument
		Cognitive Style	
Field-Independence vs. Field-Dependence	FILDINDP	Analytical vs. global orientation	Hidden Figures Test, Part I (Ekstrom, French, Harmen, & Dermen, 1976)
Conceptualizing Style	CONCSTYL	Span of conceptual category	Clayton-Jackson Object Sorting Test (Clayton & Jackson, 1961)
Reflectiveness--Impulsiveness	REFLIMPL	Deliberation vs. impulse	Impulsivity Subscale from Personality Research Test, Form E (Jackson, 1974)
Tolerance of Ambiguity	TOLRAMBQ	Inclined to accept complex issues	Tolerance of Ambiguity Scale from Self-Other Test, Form C (Rydell & Rosen, 1966)
Category Width	CATEWIDH	Consistency of cognitive range	Category Width Scale (Pettigrew, 1958)
Cognitive Complexity	COGCOMPX	Multidimensional perceptions of the environment	Group Version of Role Construct Repertory Test (Bieri, Atkins, Briar, Leaman, Miller, & Tripodi, 1966)
		Cognitive Ability	
Verbal Comprehension	VERBCOMP	Understanding the English language	Vocabulary Test, Part I (Ekstrom et al., 1976)
General Reasoning	GENLREAS	Solving specific problems	Arithmetic Aptitude Test, Part I (Ekstrom et al., 1976)
Associational Fluency	ASSOFLUN	Producing similar words rapidly	Controlled Associations Test, Part I (Ekstrom et al., 1976)
Logical Reasoning	LOGIREAS	Deducing from premise to conclusion	Nonsense Syllogisms Test, Part I (Ekstrom et al., 1976)
Induction	INDUCTON	Forming hypotheses to fit certain facts	Figure Classification Test, Part I (Ekstrom et al., 1976)
Ideational Fluency	IDEAFLUN	Generating ideas about a specific type	Topics Test, Part I (Ekstrom et al., 1976)
		Cognitive Aptitude	
General Information	GENLINFO	Recognizing factual information	General Information Subtest, ASVAB
Numerical Operations	NUMROPER	Completing arithmetic operations	Numerical Operations Subtest, ASVAB
Attention to Detail	ATTNDETL	Finding an important detail	Attention to Detail Subtest, ASVAB
Word Knowledge	WORDKNOL	Comprehending written and spoken language	Word Knowledge Subtest, ASVAB
Arithmetic Reasoning	ARTHREAS	Solving arithmetic word problems	Arithmetic Reasoning Subtest, ASVAB
Space Perception	SPACPERC	Visualizing objects in space	Space Perception Subtest, ASVAB
Mathematics Knowledge	MATHKNOL	Employing mathematical relationships	Mathematics Knowledge Subtest, ASVAB
Electronics Information	ELECINFO	Using electronics relationships	Electronics Information Subtest, ASVAB
Mechanical Comprehension	MECHCOMP	Reasoning with mechanical concepts	Mechanical Comprehension Test, ASVAB
General Science	GENLSCIE	Perceiving relationships between scientific concepts	General Science Subtest, ASVAB
Shop Information	SHOPINFO	Knowing shop tools	Shop Information Subtest, ASVAB
Automotive Information	AUTOINFO	Knowing automotive functions	Automotive Information Subtest, ASVAB

Note. These cognitive characteristics and the tests used to measure them are described in detail in Federico and Landis (1979) (Appendix).

Table 2

Summary of Stepwise Discriminant Analyses
Using Measures of Cognitive Characteristics

Step Number	Student Cognitive Measure Entered	Removed	F to Enter or Remove	Wilks Lambda (Λ)	p	Rao's V	Change in Rao's V	p of Change
			Cognitive Styles Only					
1	FILDINDP		16.82	.92	.00	16.82	16.82	.00
2	CONCSTYL		2.51	.91	.00	19.55	2.73	.10
3	COGCOMPX		1.46	.91	.00	21.16	1.62	.20

Λ = .91; $\chi^2(3) = 19.99$; $p < .001$; $\lambda = .10$.

$CN_f = .68$; $CN_g = -.14$; $R_c = .31$.

D = -.81 FILDINDP -.36 CONCSTYL +.26 COGCOMPX.

C_f = .17 FILDINDP +.63 CONCSTYL +.23 COGCOMPX -1.27.

C_g = .35 FILDINDP +.71 CONCSTYL +.22 COGCOMPX -13.39.

			Cognitive Abilities Only					
1	GENLREAS		33.36	.86	.00	33.36	33.36	.00
2	INDUCTON		4.40	.84	.00	38.50	5.14	.02

Λ = .84; $\chi^2(2) = 35.11$; $p < .001$; $\lambda = .19$.

$CN_f = -.88$; $CN_g = .18$; $R_c = .40$.

D = .88 GENLREAS +.35 INDUCTON.

C_f = .43 GENLREAS +.17 INDUCTON -.32.

C_g = .77 GENLREAS +.19 INDUCTON -8.96.

			Cognitive Aptitudes Only					
1	MATHKNOL		25.84	.89	.00	25.84	25.84	.00
2	ARTHREAS		5.11	.87	.00	31.62	5.79	.01
3	GENLSCIE		2.46	.86	.00	34.49	2.86	.10
4	NUMROPER		2.83	.84	.00	37.83	3.35	.07

Λ = .84; $\chi^2(4) = 34.38$; $p < .001$; $\lambda = .18$.

$CN_f = .87$; $CN_g = -.18$; $R_c = .40$.

D = -.32 NUMROPER -.29 ARTHREAS -.41 MATHKNOL -.33 GENLSCIE.

C_f = .67 NUMROPER +.20 ARTHREAS +.29 MATHKNOL +.61 GENLSCIE -46.17.

C_g = .72 NUMROPER +.24 ARTHREAS +.36 MATHKNOL +.65 GENSCIE -57.46.

			Cognitive Styles and Abilities					
1	GENLREAS		33.36	.86	.00	33.36	33.36	.00
2	FILDINDP		6.90	.83	.00	41.42	8.06	.00
3	INDUCTON		3.06	.82	.00	45.13	3.71	.05
4	CATEWIDH		2.66	.81	.00	48.42	3.29	.07
5	COGCOMPX		1.59	.80	.00	50.43	2.01	.16
6	IDEAFLUN		1.15	.80	.00	51.90	1.47	.22

Λ = .80; $\chi^2(6) = 45.59$; $p < .001$; $\lambda = .25$.

$CN_f = .99$; $CN_g = -.20$; $R_c = .45$.

D = -.09 FILDINDP +.03 CATEWIDH +.01 COGCOMPX -.20 GENLREAS -.02 INDUCTON -.04 IDEAFLUN +1.78.

C_f = .03 FILDINDP +.34 CATEWIDH +.27 COGCOMPX +.31 GENLREAS +.12 INDUCTON +.40 IDEAFLUN -21.68.

C_g = .17 FILDINDP +.30 CATEWIDH -.26 COGCOMPX +.61 GENLREAS +.14 INDUCTON +.45 IDEAFLUN -23.75.

Notes.

1. CN_f and CN_g = Centroids for failure and graduate groups.
2. R_c = Canonical correlation between the derived discriminant function and the set of dummy variables defining membership in the two groups.
3. D = Derived discriminant function.
4. C_f and C_g = Classification functions for failure and graduate groups.

Table 2 (Continued)

Step Number	Student Cognitive Measure Entered	Removed	F to Enter or Remove	Wilks Lambda (Λ)	p	Rao's V	Change in Rao's V	p of Change
			Cognitive Styles and Aptitudes					
1	MATHKNOL		25.84	.89	.00	25.84	25.84	.00
2	FILDINDP		7.02	.86	.00	33.78	7.94	.00
3	ARTHREAS		5.76	.83	.00	40.55	6.77	.01
4	GENLSCIE		2.73	.82	.00	43.87	3.32	.07
5	NUMROPER		3.05	.81	.00	47.65	3.78	.05
6	CATEWIDH		1.81	.80	.00	49.94	2.29	.13
7	COGCOMPX		1.78	.80	.00	52.27	2.28	.13
8	SPACPERC		1.64	.79	.00	54.35	2.13	.14
9		MATHKNOL	.90	.79	.00	53.18	-1.17	1.00
10	CONCSTYL		1.20	.79	.00	54.75	1.57	.21

Λ = .79; $\chi^2(8) = 47.58$; $p < .001$; $\lambda = .28$.

$CN_f = -1.02$; $CN_g = .21$; $R_c = .46$.

D = .45 FILDINDP +.15 CONCSTYL −.22 CATEWIDH −.21 COGCOMPX +.37 NUMROPER +.30 ARTHREAS −.18 SPACPERC +.38 GENLSCIE.

C_f = −.28 FILDINDP +.67 CONCSTYL +.31 CATEWIDH +.28 COGCOMPX +.59 NUMROPER +.33 ARTHREAS +.40 SPACPERC +.53 GENLSCIE −68.14.

C_g = −.10 FILDINDP +.73 CONCSTYL +.27 CATEWIDH +.26 COGCOMPX +.66 NUMROPER +.39 ARTHREAS +.38 SPACPERC +.60 GENLSCIE −76.55.

			Cognitive Abilities and Aptitudes					
1	GENLREAS		33.36	.86	.00	33.36	33.36	.00
2	MATHKNOL		7.51	.83	.00	42.13	8.77	.00
3	INDUCTON		3.50	.82	.00	46.39	4.26	.04
4	GENLSCIE		2.76	.80	.00	49.82	3.43	.06
5	LOGIREAS		1.81	.80	.00	52.12	2.30	.13
6	ARTHREAS		1.62	.79	.00	54.20	2.09	.15

Λ = .79; $\chi^2(6) = 47.39$; $p < .001$; $\lambda = .26$.

$CN_f = 1.01$; $CN_g = -.21$; $R_c = .46$.

D = −.56 GENLREAS +.21 LOGIREAS −.25 INDUCTON −.22 ARTHREAS −.25 MATHKNOL −.23 GENLSCIE.

C_f = −.72 GENLREAS −.32 LOGIREAS +.13 INDUCTON +.46 ARTHREAS +.56 MATHKNOL +.51 GENLSCIE −42.46.

C_g = −.45 GENLREAS −.39 LOGIREAS +.16 INDUCTON +.50 ARTHREAS +.61 MATHKNOL +.55 GENLSCIE −52.49.

			Cognitive Styles, Abilities, and Aptitudes					
1	GENLREAS		33.36	.86	.00	33.36	33.36	.00
2	MATHKNOL		7.51	.83	.00	42.13	8.77	.00
3	FILDINDP		4.31	.81	.00	47.38	5.25	.02
4	GENLSCIE		3.48	.80	.00	51.72	4.34	.04
5	LOGIREAS		2.30	.79	.00	54.66	2.94	.09
6	CATEWIDH		2.02	.78	.00	57.28	2.63	.10
7	INDUCTON		2.69	.77	.00	60.83	3.54	.06
8	NUMROPER		1.98	.76	.00	63.49	2.66	.10
9		MATHKNOL	.86	.77	.00	62.33	-1.15	1.00
10	COGCOMPX		2.00	.76	.00	65.02	2.69	.10
11	SPACPERC		1.39	.75	.00	66.93	1.90	.17
12	ARTHREAS		1.62	.75	.00	69.18	2.25	.13

Λ = .75; $\chi^2(10) = 58.15$; $p < .001$; $\lambda = .34$.

$CN_f = -1.10$; $CN_g = .23$; $R_c = .50$

D = .33 FILDINDP −.26 CATEWIDH −.17 COGCOMPX +.43 GENLREAS −.16 LOGIREAS +.22 INDUCTON +.21 NUMROPER +.20 ARTHREAS −.17 SPACPERC +.31 GENLSCIE.

C_f = −.07 FILDINDP +.29 CATEWIDH +.28 COGCOMPX −.91 GENLREAS −.26 LOGIREAS +.10 INDUCTON +.29 NUMROPER +.45 ARTHREAS +.37 SPACPERC +.56 GENLSCIE −69.82.

C_g = .08 FILDINDP +.24 CATEWIDH +.26 COGCOMPX −.67 GENLREAS −.32 LOGIREAS +.13 INDUCTON +.74 NUMROPER +.49 ARTHREAS +.35 SPACPERC +.63 GENLSCIE −77.41.

Notes.

1. CN_f and CN_g = Centroids for failure and graduate groups.
2. R_c = Canonical correlation between the derived discriminant function and the set of dummy variables defining membership in the two groups.
3. D = Derived discriminant function.
4. C_f and C_g = Classification functions for failure and graduate groups.

Table 3

Means, Standard Deviations, and Univariate F-Ratios for BE/E Failures and Graduates on Tests Measuring Cognitive Characteristics

Cognitive Characteristic	Failures (N = 35)		Graduates (N = 172)		Univariate
	M	SD	M	SD	F
Cognitive Style					
FILDINSP	2.34	3.38	5.20	3.82	16.82***
CONCSTYL	11.06	3.63	12.70	4.07	4.90*
REFLIMPL	4.06	2.79	3.33	3.13	1.62
TOLRAMBQ	5.57	2.85	5.70	1.98	0.10
CATEWIDH	32.34	12.61	31.70	9.59	0.12
COGCOMPX	77.20	20.04	72.04	17.71	2.36
Cognitive Ability					
VERBCOMP	7.40	3.49	8.95	3.23	6.54*
GENLREAS	5.00	3.05	8.17	2.95	33.36***
ASSOFLUN	9.31	4.34	10.97	4.91	3.44
LOGIREAS	1.97	4.06	2.76	4.51	0.92
INDUCTON	50.17	15.21	59.72	16.95	9.53**
IDEAFLUN	10.00	3.50	11.59	4.34	4.12*
Cognitive Aptitude					
GENLINFO	55.29	5.44	58.78	6.97	7.81**
NUMROPER	48.60	6.71	53.92	7.45	15.29***
ATTNDETL	49.20	7.49	51.16	9.57	1.30
WORDKNOL	55.80	6.22	59.48	6.30	9.95**
ARTHREAS	53.00	8.37	60.20	8.36	21.54***
SPACPERC	55.60	7.83	56.24	11.15	0.10
MATHKNOL	53.09	5.87	60.44	8.13	25.84***
ELECINFO	57.34	5.30	60.58	6.58	7.48**
MECHCOMP	56.02	6.81	59.62	6.74	8.21**
GENLSCIE	54.80	11.53	60.45	7.66	13.10***
SHOPINFO	56.57	5.84	57.78	6.70	0.98
AUTOINFO	55.97	6.06	57.55	8.02	1.21

*p < .05 ($F(1,205) \geq 3.84$).

**p < .01 ($F(1,205) \geq 6.64$).

***p < .001 ($F(1,205) \geq 10.83$).

Table 4

Prediction Results Based on Derived Classification Functions

Classification Function	Actual Failures		Actual Graduates		χ^2
	Predicted Failures	Predicted Graduates	Predicted Failures	Predicted Graduates	
Equal Probability					
Styles (S)	68.60	31.40	38.40	61.60	10.79**
Abilities (A)	74.30	25.70	26.20	73.80	29.89*
Aptitudes (P)	77.10	22.90	23.30	76.70	38.58*
S x A	71.40	28.60	23.80	76.20	30.33*
S x P	80.00	20.00	22.70	77.30	43.66*
A x P	80.00	20.00	20.90	79.10	47.51*
S x A x P	80.00	20.00	20.90	79.10	47.51*
Adjusted Probability					
Styles (S)	0.00	100.00	0.60	99.40	0.20
Abilities (A)	14.30	85.70	3.50	96.50	6.74**
Aptitudes (P)	11.40	88.60	2.90	97.10	5.08***
S x A	22.90	77.10	3.50	96.50	17.30*
S x P	25.70	74.30	4.10	95.90	19.10*
A x P	28.60	71.40	5.20	94.80	19.00*
S x A x P	34.30	65.70	3.50	96.50	34.74*

*$\chi^2(1) \geq 10.83$; $p < .001$.

**$\chi^2(1) \geq 6.64$; $p < .01$.

***$\chi^2(1) \geq 3.84$; $p < .05$.